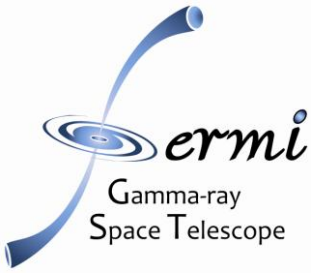


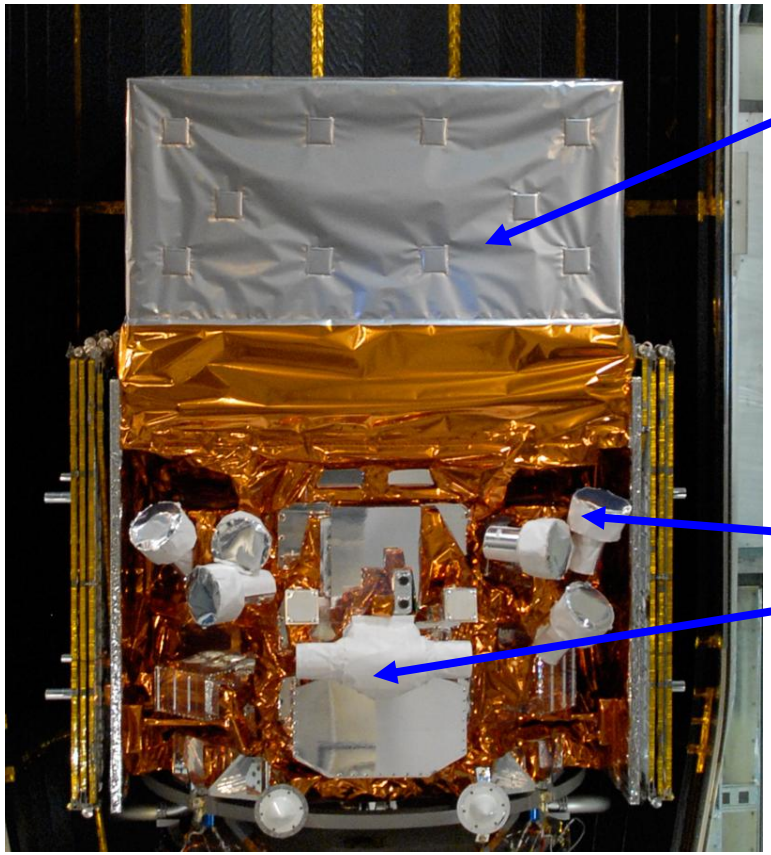
Fermi's Restless Universe

Dr. Julie McEnery

Project Scientist

NASA Goddard Space Flight Center

The Observatory 2008



Large AreaTelescope (LAT)
20 MeV - >300 GeV

Gamma-ray Burst Monitor (GBM)
8 keV - 40 MeV

Spacecraft Partner:
General Dynamics

Fermi Mission Status

- We have recently concluded our first year of successful observations of the high-energy gamma-ray sky. Data are now public.
- Both the Large Area Telescope and the Gamma-ray Burst Monitor are working beautifully.
- We have discovered many new classes of gamma-ray emitting objects, some of which we will highlight in today's briefing

The Fermi Sky

- Wild variations on all timescales from less than seconds (e.g., gamma-ray bursts) to years (galaxies)
- More than 1000 sources discovered
  - Nearly half are identified
- New classes of objects detected
  - Pulsars seen only in gamma-rays
  - Gamma-ray emitting High-mass X-ray binaries
  - Radio and starburst galaxies

The Fermi Skymap

Movie: Fermi's mapping progress

Virgo region

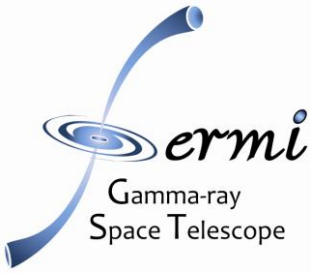
All-sky image highlighting north polar region

and

Movie of blazars at the north galactic pole

Highlights

- Fermi has discovered
  - More than 500 gamma-ray blazars – the most prevalent source class by far.
  - 16 pulsars via gamma-rays and detected more than 30 others.
  - GeV gamma rays from two compact binary systems.
  - GeV emission from 12 GRBs; 250 seen with Fermi at low energy
- We're starting to see what we were missing!



New Results from Fermi's Large Area Telescope

Professor Peter Michelson

Principal Investigator

Stanford University

Overview

- Fermi's Large Area Telescope is a multi-national and multi-agency collaboration
- In today's press conference, we will showcase
  - High-mass X-ray binaries (HMXBs)
  - Gamma-ray bursts

High Mass X-ray Binaries

- First detections of GeV intensity variations revealing orbital motion – a new class of high-energy emitters.
  - Identified mysterious EGRET sources:
    - LSI +61°303 26-day orbital period
    - LS 5039 3.9-day orbital period
- These sources also seen at TeV energies by ground-based telescopes

HMXB animation

Animation of a high-mass X-ray binary

Record-setting Fermi GRBs

- Fermi's Large Area Telescope (LAT) detected GeV gamma-rays from 12 bursts so far
- Three have set records:
  - **Greatest total energies** (~10^{54} ergs, GRB 080916C)
  - **Fastest motions** (99.99995% of speed of light, GRB 090510)
  - **Highest-energy photons** (33.4 GeV, GRB 090902B)
- First observation of persistent GeV afterglows lasting from minutes to hours.

Setting limits on Quantum Gravity

- Central challenge for nearly a century has been to unify gravity with the other forces of nature:
  - Requires a quantum theory of gravity
  - On general grounds, expect quantum gravity effects to be large on scale of the Planck length defined by three fundamental constants of nature (*c*, *h* and *G*):

$$l_{\text{Planck}} = 1.6 \times 10^{-35} \text{ meters}$$

  - Quantum theory of light tells us the energy of a photon increases as its wavelength decreases:

if photon wavelength equals Planck length then

$$E_{\text{photon}} = E_{\text{Planck}} = 1.2 \times 10^{19} \text{ GeV}$$

Setting limits on Quantum Gravity

- Some QG theories predict that higher-energy photons are more affected by the quantum nature of space-time and will travel more slowly than lower-energy photons.
  - Violates Einstein's Special Theory of Relativity
  - Can be tested using GRBs, with shorter bursts providing the best limits
- GRB090510 has limited this effect to 0.9 second over a baseline of 7 billion light-years

  → Limits the scale of QG effects to be larger than Planck energy. Einstein's relativity wins again!

Visualizing Quantum Gravitational Effects

Movie: Gamma-ray burst photon delay as expected by quantum gravity

Conclusions

- Fermi has had a great first year!
- Fermi has found more than 5 times as many high-energy sources as were previously known
  - including several new kinds of high-energy sources never seen before.
- Fermi is transforming our knowledge of the high-energy Universe from a handful of known sources to complete classes of objects.
- Fermi is probing physics on interesting scales with gamma-ray bursts
- There is much more to come!